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DETERMINING POSSIBLE CORRELATIONS BETWEEN PSEUDO DYKSTRA-PARSONS COEFFICIENT AND DEPOSYSTEM TYPES

(PROJECT BE1, Task 1, Milestone A in FY86 Annual Plan dated March 1986)

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ABSTRACT

Results of a limited study of 26 Department of Energy (DOE) cost-shared enhanced oil recovery (EOR) projects indicate no definite relationship between the various deposystems and the calculated pseudo Dykstra-Parsons coefficients (V_{PDP}) in these deposystems. The calculated V_{PDP} values for the various deposystems are not confined within narrow limits; sometimes even within a single field the Dykstra-Parsons coefficient of permeability variation (V_{DP}) fluctuate over a wide range. In such fields the fluctuations in V_{PDP} values would also be correspondingly large. It is recommended that selection of a deposystem with high EOR potential for detailed study of reservoir heterogeneities and their effects be accomplished by the alternate method proposed in the FY86 Plan. This method is based on the occurrence of significant oil accumulations and EOR projects in the deposystem.

OBJECTIVE

The objective of this limited study is to determine whether a relationship can be established between the deposystem and calculated pseudo Dykstra-Parsons coefficients (V_{PDP}) in these deposystems. An additional objective of this limited investigation is that if a relationship is found between deposystem type and calculated V_{PDP} values, the study will be extended to cover additional reservoirs for a more comprehensive evaluation of the relationship between the V_{PDP} values, the geological heterogeneities, and the mobility ratios. In the event that no definite relationship can be recognized an alternative approach, suggested in the FY86 Annual Plan, will be adopted for selecting a suitable deposystem for heterogeneity research. Since ideal V_{PDP} values not only give a measure of the reservoir heterogeneity but also a measure of the sweep efficiency and the mobility ratio in the reservoir, the presence of a definite relationship between deposystems and the V_{PDP} values would greatly help in the selection of a deposystem with high EOR potential for heterogeneity research. The candidate deposystem for heterogeneity research for EOR will be one having reservoirs with high residual oil saturation after waterflood (the actual percentage depending upon the EOR process), significant geological heterogeneities, and comparatively poor sweep efficiency because of the geological heterogeneities.

If the V_{PDP} coefficients are indicative of the heterogeneities and sweep efficiencies of the different deposystems and if they are confined to certain ranges (say within 10 to 15 percent points) then these coefficients could be used to evaluate the deposystems for EOR potential.

INTRODUCTION

The research strategy in the reservoir characterization program is to first select one major depositional system based on its EOR potential. The program then envisages detailed analysis of the various heterogeneities in the deposystem for developing quantitative methods for accurate prediction of flow patterns, recovery, and the spatial distribution of oil remaining after each process.

The ideal candidate deposystem for heterogeneity research will be the one which is a habitat for large oil accumulations and which has reservoirs with large original oil in place and fairly high residual oil saturation (say >40%)

after waterflooding. Because of the various geological heterogeneities the reservoirs in the selected deposystem will have relatively poor sweep and displacement efficiencies so that there is good potential for significant oil recovery through improvement in understanding the various geological heterogeneities in the reservoirs.

In selecting a suitable deposystem for heterogeneity research, the existence of a relationship between the type of deposystem and some measure of the aggregate heterogeneity in the reservoir will be determined. A measure of the heterogeneity at a particular location in a stratified reservoir can be obtained from the Dykstra-Parsons coefficients (V_{DP}) of permeability variations and stratification. In the 1984 National Petroleum Council (NPC) study on 2,500 reservoirs subjected to waterflood, a correlation was developed between the aggregate reservoir heterogeneity (as given by the V_{DP} values), the volumetric sweep efficiency, and the mobility ratio of a reservoir subjected to waterflooding. This correlation was obtained theoretically from the Higgings-Leighton stream model for a five-spot pattern consisting of 100 layers and specific reservoir data consisting of the coefficient of permeability variation (V_{DP}), the volumetric sweep efficiency, and the mobility ratio. From the developed correlations, a coefficient of permeability variation can be recalculated for a given reservoir if the sweep efficiency and the mobility ratio of the reservoir are known. This coefficient of permeability variation so obtained is called the pseudo Dykstra-Parsons coefficient, and it is a measure of the permeability variation, the volumetric sweep efficiency, and the mobility ratio in the reservoir.

The V_{PDP} values range from 0.0 for a perfectly homogeneous reservoir to 1.0 for a completely heterogeneous reservoir. The sweeping efficiency in the reservoir can be obtained from the graphical relationship provided V_{PDP} values and a few other reservoir data, like the mobility ratio and the water oil ratio in the reservoir are available. From the graphical relationship a V_{PDP} value of 1.0 will indicate zero sweep efficiency of the reservoir.

ANALYSIS OF DATA

The relevant geological data from the 26 DOE cost-shared EOR projects were first extracted from the DOE reservoir data base. These data consist of the field and reservoir names, lithology, average reservoir porosity and permeability values, and the calculated pseudo Dykstra-Parsons coefficients (V_{PDP}). Only 21 V_{PDP} coefficients were obtained from this search as there were no V_{PDP} entries in the reservoir data base for five projects. Furthermore, six additional reservoirs had the default, average V_{PDP} values of 0.72 because of lack of reliable reservoir data from these reservoirs.

Information on the environment of deposition was gathered through a computer search of geological information for each reservoir studied. This information was not readily available in the literature for most of the reservoirs, and in some cases, the search required a detailed review of available information from various sources. Besides the environment of deposition, the literature was also reviewed for any information on permeability variation in the reservoir, like the Dykstra-Parsons coefficient calculated from individual well permeability data.

INTERPRETATION OF DATA

Results of the analysis of the V_{PDP} data and environment of deposition for 16 DOE cost shared EOR projects are shown in table 1. The reservoirs belong to four main environments (fluvial, deltaic, barrier and offshore bars, and turbidites). Some reservoirs represent transitional conditions between two environments. It may be seen in table 1 that the V_{PDP} values are not diagnostic of any particular environment of deposition. For example, the V_{PDP} values ranged between 0.5 (or less) and 0.90996 in fluvial and fluvial-deltaic environments. The fluctuation of V_{PDP} values in turbidites was from 0.92 to 0.60.

Even within a single field sometimes there was a large variation in the V_{DP} values, depending upon where in the deposystem the permeability information was obtained. As an example, in North Burbank field (fluvial environment), the coefficients varied from 0.40 to 0.87 within a distance of 4 to 5 miles. The variation in reservoir heterogeneity could be even larger in other areas in the same environment. A second example is Bell Creek field in Montana which has been interpreted to be a barrier bar. The calculated V_{PDP} value is 0.50 although the Dykstra-Parsons permeability variations ranged from 0.34 in the more homogeneous central part to 0.70 in the lagoonal side of the bar. Again the variation could be even larger in other areas of the bar. From the above discussion on the variation in the V_{DP} values within a single field it follows that if the same field is divided up into a number of 5-spots and V_{PDP} values calculated for each 5-slot then these values will also show large variations. This indicates that it will not be possible to obtain a measure of the reservoir heterogeneity from one isolated calculation of V_{PDP} value in the reservoir.

RESULTS OF STUDY

Results of this limited study indicate that the calculated V_{PDP} values in the various deposystems are not confined within narrow limits. Even in a single field within a particular deposystem, the coefficients (V_{DP}) sometimes show wide variation due to appreciable lateral geological heterogeneities.

CONCLUSIONS

From this study, it may be concluded that the calculated V_{PDP} coefficients are not diagnostic of the aggregate heterogeneities within a given deposystem. The values do not represent the weighted average values for a particular deposystem. Owing to their large variations, neither can the calculated coefficients be construed to give a reliable measure of the sweeping efficiency within a deposystem. It would seem that any conclusion on geological heterogeneity or the sweep efficiency in reservoirs based on limited V_{PDP} values could be erroneous.

RECOMMENDATIONS

Based on results of this limited study, the alternate approach as proposed in the FY86 Annual Plan is recommended. In this method deposystems are first identified from literature which are major habitats of oil in the North American Continent. From Toris or similar data base and from other sources, EOR projects will be identified which are being implemented in the selected deposystems. From this study a deposystem will be selected which has significant oil accumulations and at the same time has good potential for EOR.

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TABLE 1. <u>Pseudo Dykstra-Parsons coefficients and the depositional environments for DOE cost-shared EOR projects</u>

Field	Reservoir/Formation	Pseudo Dykstra-Parsons Coefficient (V_{PDP})	Environment of Deposition	Comments
North Burbank	Burbank/Burbank Sand	0.6821	Fluvial	Dykstra Parsons coefficients indicate large varia in the field. For example in Tract 97 it ranges 0.40 to 0.65. In Tract 49, it has a value of 0.8
Weeks Island	"S" Sand Reservoir	0.50	Fluvial	A V_{PDP} value of 0.50 indicates that the calculate permeability variation was less than 0.50.
Kern Front	Main/Chanac	0.73168	Fluvial	
El Dorado	All/Admire	0.90996	Fluvial-Deltaic	
Bradford	Bradford/Third Sand	0.65792	Deltaic	
Big Muddy	Frontier/Frontier	0.70215	Barrier Bar	A complete interpretation of the environment of deposition has not yet been made. Some claim that sands in the reservoir were deposited under deltaic environment.
Bell Creek	Muddy/Muddy	0.50	Barrier Bar	The calculated Dykstra Parsons coefficient in the 160 acre pilot ranged from 0.34-0.70.
Stanley Stringer	Burbank/Burbank	0.72	Offshore bar	The average value of 0.72 was assigned to reservoirs for which insufficient data was available to calculate the permeabiity variation.
Huntington Beach	Hunt Ave Area/Puente	0.92388	Turbidites	
Coalinga	Temblor/Temblor Zone	0.67822	Turbidites	
Midway Sunset	Republic/Spellacy	0.78505	Turbidites	
Wilmington	East Area Block VI/Puente	0.76639	Turbidites	
Wilmington	Harbor Area Fault/Puente	0.6175	Turbidites	
Wilmington	Terminal Area Fault/Puente	0.65343	Turbidites	
Wilmington	Terminal Area Fault/Puente	0.60857	Turbidites	
Wilmington	Town Lot Area Fault/Puente	0.6778	Turbidites	